Aquifer Storage & Recovery

What is it?
Who regulates it?
How does it impact Public Water Supplies?

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Aquifer Storage & Recovery
vs
Aquifer Storage

- Aquifer Storage & Recovery (ASR)
  - Formal ASR involves using a single well designed for both injecting and recovery of water
  - Confined aquifers common
- Aquifer Storage (AS)
  - Spreading grounds & recharge basins common
  - Single purpose injection wells
  - Unconfined aquifers common

Aquifer Storage & Recovery

- ASR used to achieve two objectives:
  - 1) harvest excess water for later use;
  - 2) minimize cost & impact of surface storage.
- ASR wells may have secondary objectives,
  - subsidence control
  - prevention of salt/brackish water intrusion.

Aquifer Storage

- AS water injected into aquifer using
  - Spreading grounds
  - Impoundments
  - Wells
- AS water recovered elsewhere in aquifer
  - Conventional wells
  - Mitigation
    - Wetlands
    - Surface water flow

Bit of ASR/AS History

- ASR around 25 yrs, AS much longer
- Florida most active ASR region
  - Geology/topography not conducive to reservoirs or useful Aquifer Storage due to
    - Wetlands
    - Leaky formations
    - Subsidence and sinkholes
  - ASR good for brackish deep aquifers
  - Seasonally abundant water stored for dry high demand season

ASR/AS History (cont.)

- Early Florida Approach
  - – Drill single ASR well
  - – Very limited water quality tests
    - Belief is that injected water treated by aquifer
    - Evidence of aquifer treatment capacity
  - – Injection/Recovery tests only
    - Multiple injection/recovery cycles for a test
    - High volume injection – untreated
    - Recovery – check Conductivity/TDS
  - – Over 40 ASR systems operational by 2002

ASR/AS History (cont.)

- Issues emerge in Florida
  - BioGeochemistry
  - Well clogging
  - Poor recovery
- CERP proposed ASR, Feds get cautious
  - Geochemistry
  - Aquifer hydraulics, pressure responses
  - Aquifer structure

ASR/AS History (cont.)

- CERP findings similar worldwide (50 sites)
  - 20 fresh & 30 brackish water sites
    - Unconsolidated
    - Bedrock
  - Well clogging & redevelopment common
    - TSS
    - Precipitation
    - Organic fouling

ASR/AS History (cont.)

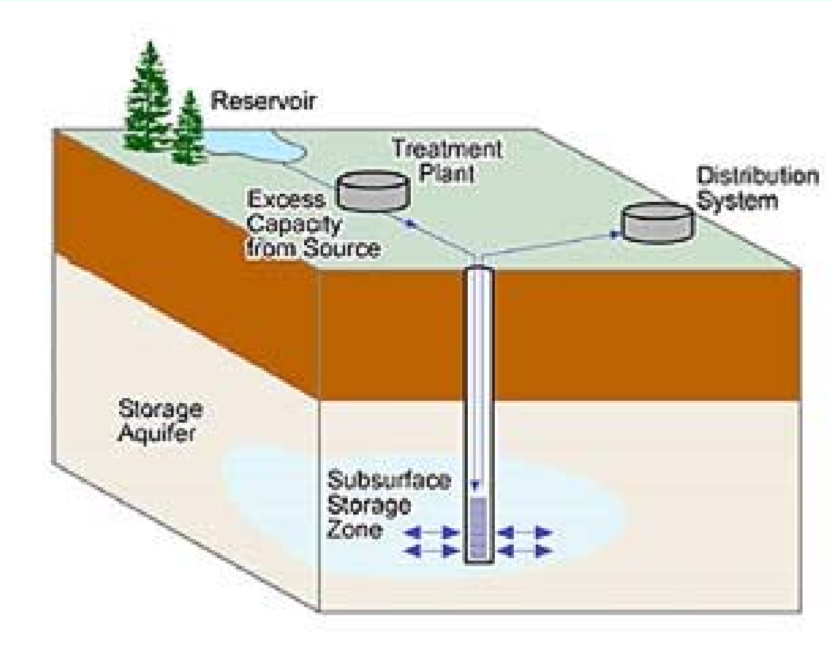
- Geochemistry
  - Metals – As, Fe, Mn, Ni, Co, Hg
  - Other – Fl, radionuclides
  - Organics – leaching, disinfection byproducts
- Costs/1000 gal
  - $1.32 to $36.08 recovered water for all sites
  - $5.22 to $13.85 recovered water fresh water sites
  - 2002 $$$

ASR/AS History (cont.)

- Wisconsin

Great News!

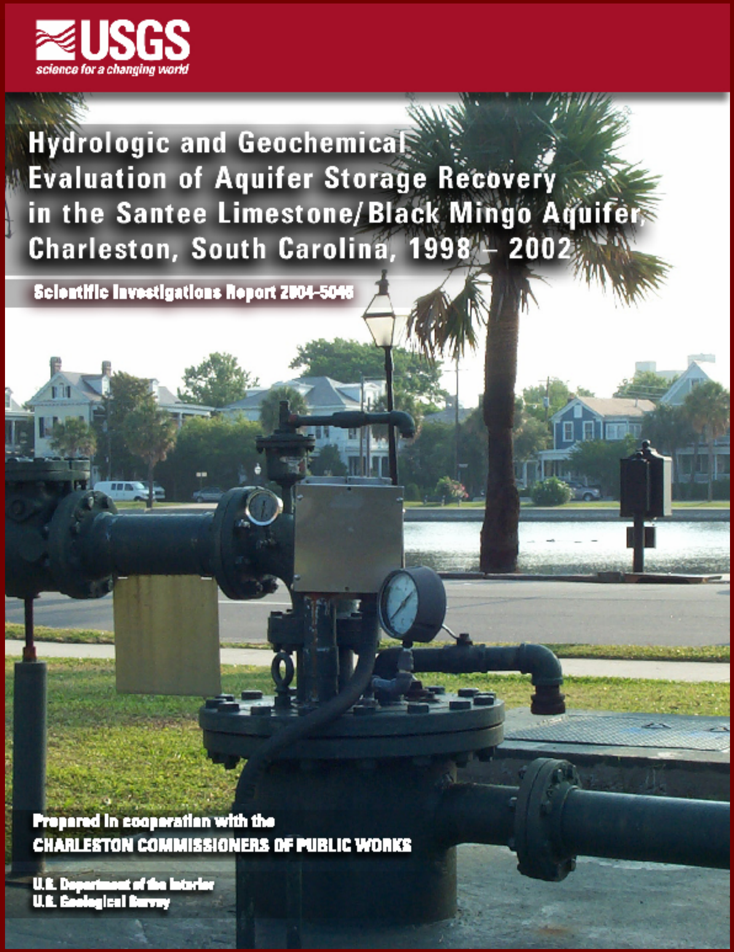
Due to negative test results (primarily arsenic contamination), the City of Green Bay has dropped its proposal to use Aquifer Storage and Recovery (ASR). The Wisconsin Dept. of Natural Resources is requiring the city to continue pumping **out** the test wells, to remove the oxygen and contaminated water created by the tests. It's a shame the City had to waste precious time and more than $1 million in ratepayers' money on such an obviously bad idea. They refused to listen to DNR warnings or our testimony at the hear-



ASR/AS History (cont.)

Charleston, South Carolina

- Typical of current ASR preliminaries
- Iterative & staged approach
- Extensive aquifer investigation
    - Hydrogeology
    - Geochemistry
    - Operational issues
- Modeling aquifer response
    - flow & pressure response
    - geochemistry
- Pilot well & injection test
- Test well
    - 75’ sandy limestone aquifer
    - 4 injection & recovery cycles
    - 1 to 6 month storage time
    - 1.8 to 1.9 million gal/cycle
    - 21% to 34% recovery



ASR/AS History (cont.)

- Long History for Aquifer Storage
  - Spreading basins most common
    - California coastal basins
    - Ogalalla Aquifer
  - Injection well use growing, special uses
    - Salt water intrusion barriers
    - Waste water disposal

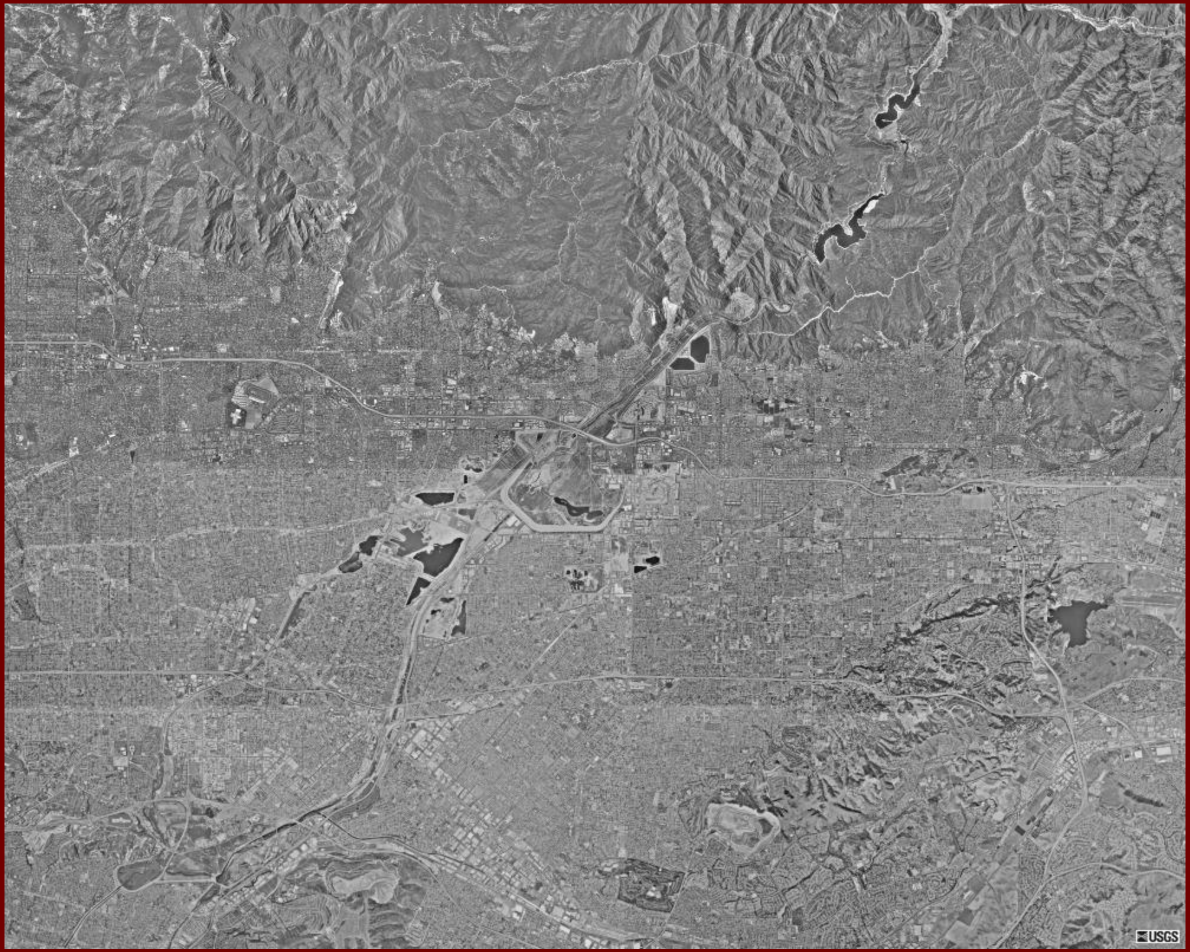
ASR/AS History (cont.)

San Gabriel Basin

Alluvial fan basin fill
- becomes finer to south
- Whitter Narrows only outlet

Spreading Basin
- 400’ high mound
- builds/dissipates in 3 months
- also recharged imported water

Multiple water systems



ASR/AS History (cont.)

- Orange County “Waste Water” injection
  - High level of treatment
    - micro-filtration
    - reverse osmosis
    - UV
    - H^2O^2
    - Need to add mineral salts prior to injection
  - Treated water injected into regional unconfined/semi-confined aquifer
  - Managing public perception critical

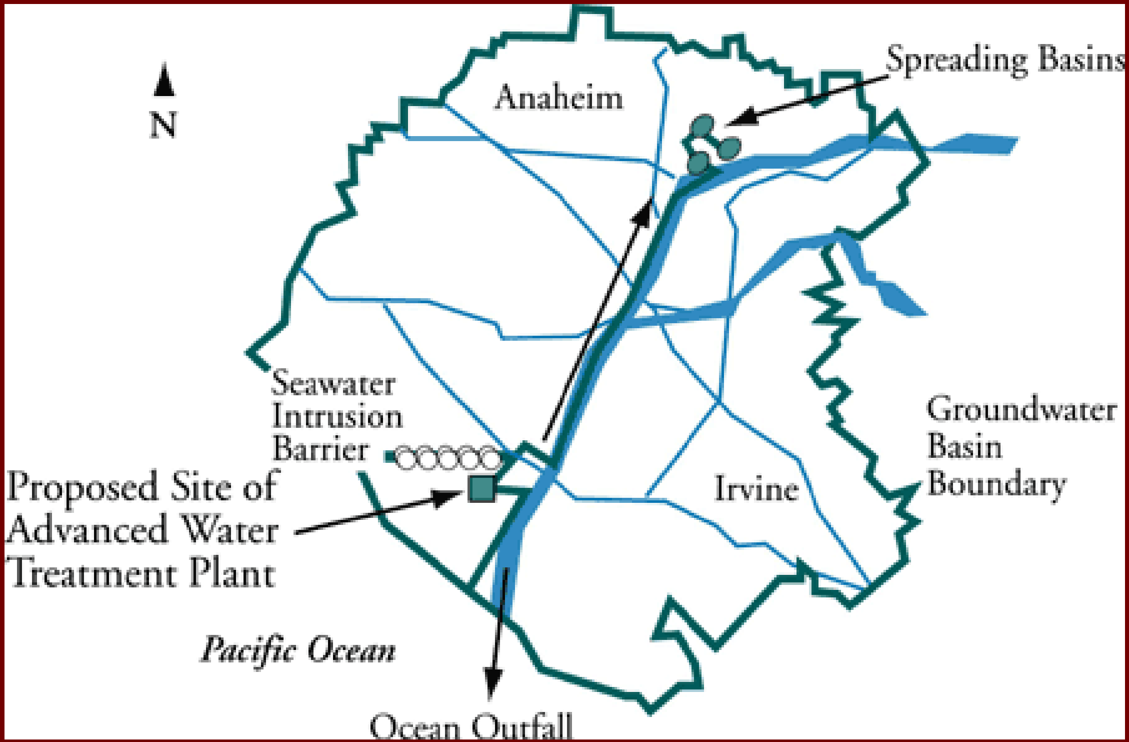
ASR/AS History (cont.)

Orange County Aquifer Storage

-Create intrusion barrier

-Increased stored water

-Note spreading basins



ASR/AS Regulation

- ASR/AR Wells are Class V wells under 40 CFR Part 146 UIC rules
- Montana does NOT have Class V UIC regulatory authority, EPA Region 8
  - Montana authority over wells not affected
- Spreading grounds, recharge basins
  - If wider than they are deep
  - Not regulated Class V well

ASR/AS Regulation (cont)

- EPA requested information:
  - Info about property owner, site operator, responsible party, contacts.
  - Project plan description
  - Source of injectate,
  - Injection procedures, injection rate, volume and pressure
  - Intended receiving formation,
  - Hydrologeology of the area.
  - Overlying and underlying aquifers that could be impacted,
  - The effect of injection activities on these aquifers,
  - Public and private wells within 1 mile of the project area,
  - Whether wells are completed in the intended receiving formation, and the effect of injection activities on these wells.

ASR/AS Regulation (cont)

- More EPA requested information:
  - Aerial extent of the aquifer (i.e. fill-up volume) that would be impacted by proposed injection based on proposed injection volumes and rates.
  - Identify all outcrops of the formation to receive injectate and any potential to create artificial springs. Identify mechanisms which will increase the volume of ground water infiltration into nearby surface water bodies.
  - Identify all erosional intersections between the proposed formation to received injectate and potentially affected surface water drainage systems.
  - Map of the site location (1:24,000 topographic map or similar)
  - Hydrogeologic description, location, depth, and current use of the receiving formations.
  - Completion diagram showing the construction plans for proposed injection well(s).

ASR/AS Regulation (cont)

- More EPA requested information:
  - Aquifer characteristics: transmissivity, storage coefficient, hydraulic conductivity, saturated thickness, information from drawdown tests and specific capacity
  - If injection is into an alluvial aquifer, provide locations of surface water bodies, i.e. rivers, streams, and lakes, within one mile of injection site
  - Analysis of the water to be injected including constituents regulated under the Safe Drinking Water Act (SDWA), major anions and cations, ambient temperature and pH, presented as tabular data
  - Analysis of the fluids in the receiving formation(s) including constituents regulated under the Safe Drinking Water Act (SDWA), major anions and cations, ambient temperature and pH, presented as tabular data.

ASR/AS Regulation (cont)

- More EPA requested information:
  - Evaluate the impact of injected water on the receiving formation, plot the major anions and cations from the above analyses of the injectate, the receiving formation fluids, and mixed fluids on a tri-linear diagram or Piper diagram. Provide a brief assessment regarding the compatibility of the injected water and the receiving formation fluids.
  - Completion diagram showing the construction plans for proposed injection well(s).
  - A brief description of contingency plans for treating the well(s) to prevent or remediate bacterialogical or mineral buildup in the well, which could affect the injection operation
  - Briefly describe planned treatment of injectate proposed prior to injection, such a filtering to remove particulates which might plug the receiving formation

ASR/AS Regulation (cont)

- More EPA requested information
  - Briefly describe proposed monitoring program, including tracking of injectate volume, proposed for the operation
  - Presence of any ground water contamination plumes near the project area that could affect or be affected by injection activity
- Negotiate w/EPA re: permit information/requirements
- EPA requested information is similar to HB 831 requirements

ASR/AS Regulation (cont)

- Other regulatory elements
  - National Primary Drinking Water Regulations
    - Injected water must meet Treatment Standards
    - Includes pathogens, virus, etc
  - Well construction rules
    - Injection wells will need to exceed Montana rules
    - EPA likely require more – impact to other aquifers
  - Spreading & Recharge Basins
    - Dam Safety rules if over 50 ac/ft impounded
    - 100% excavated basins OK

ASR/AS Regulation (cont)

- Water Rights
  - ASR/AS introduces complexity not contemplated by Montana rules
  - Technical community needs to lead attorneys
- Legal Issues
  - Once injected, who owns water?
  - Lost water?
  - Recovery by other wells within affected zone
  - Adverse water quality impacts to other users

Public Water Supply Impacts

- Water Quality
  - – Injecting impaired quality water
    - ASR regulatory controls mostly eliminate practice
  - – Injection caused changes to mineral solubility
    - Changes in redox – metals in solution
    - "Lost" water expands redox affected areas
    - Affected water available for recovery by others
  - – Injection may push past biogeochemical threshold (i.e. AMD is hard to turn off)

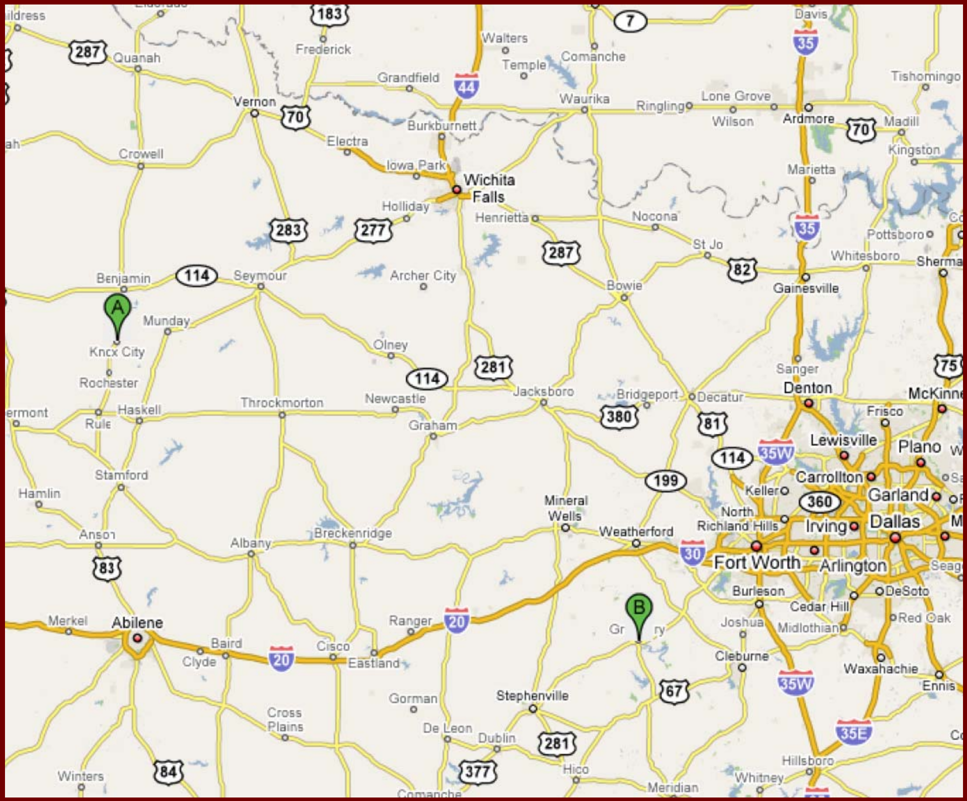
Public Water Supply Impacts (cont.)

- Water Quantity
  - Impacts highly dependent on situation
  - Impacts dependent on proximity to ASR/AS
  - Full design recovery (% of injectate) will most likely stress nearby water users
  - ASR/AS is aggressive water management

Public Water Supply Impacts (cont.)

- Texas AS & ASR Examples

  - Aquifer Storage near Knox City "Seymour Project"
  - ASR near Granbury "Johnson County Project"
  - Part of Brazos G Regional Water Plan



Public Water Supply Impacts (cont.)

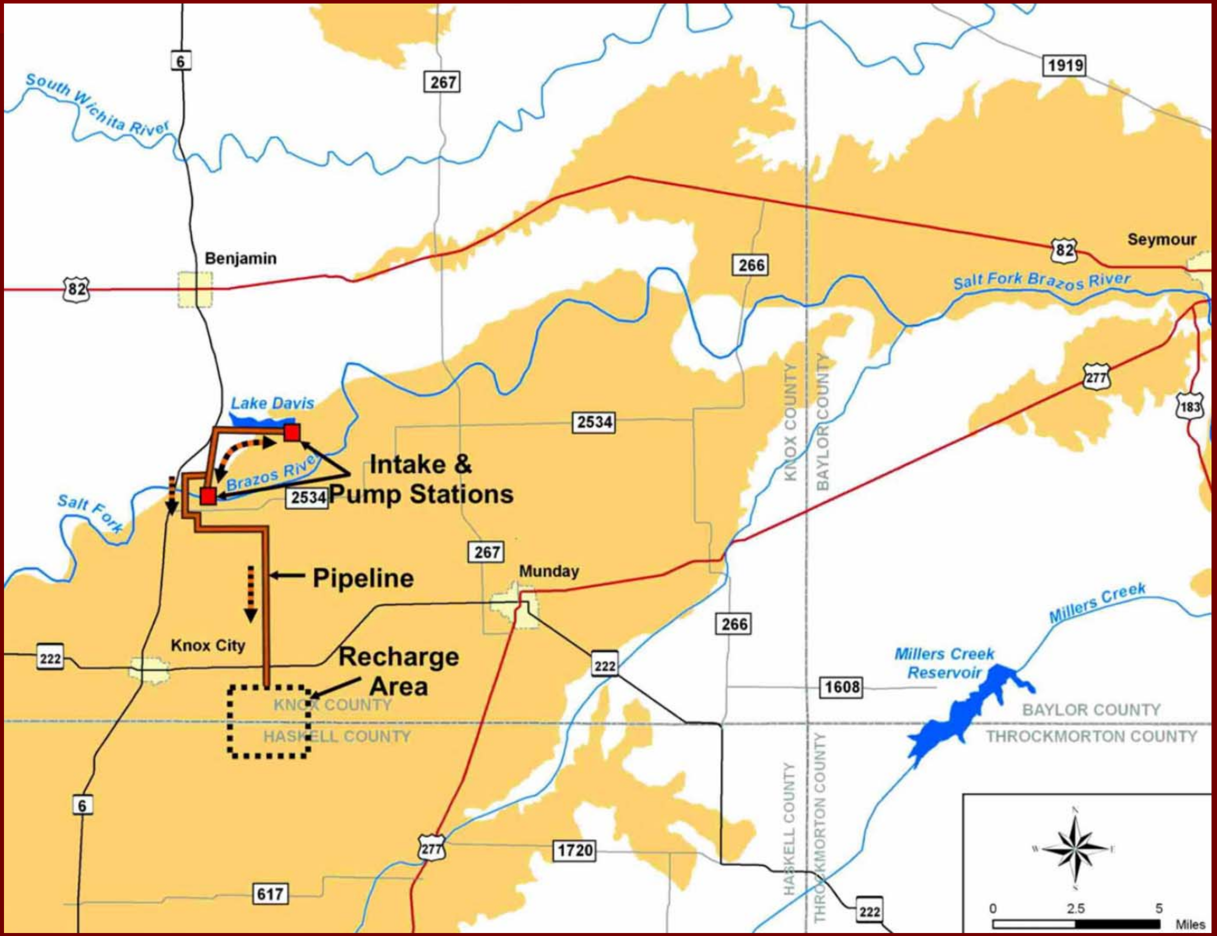
Diversions from Lake Davis will average 3,750 ac/ft year

Spreading Grounds include simple berms to store water in topographic lows.

Available recharge will vary from 0 to 9000 ac/ft/yr

Agricultural irrigation is intended use

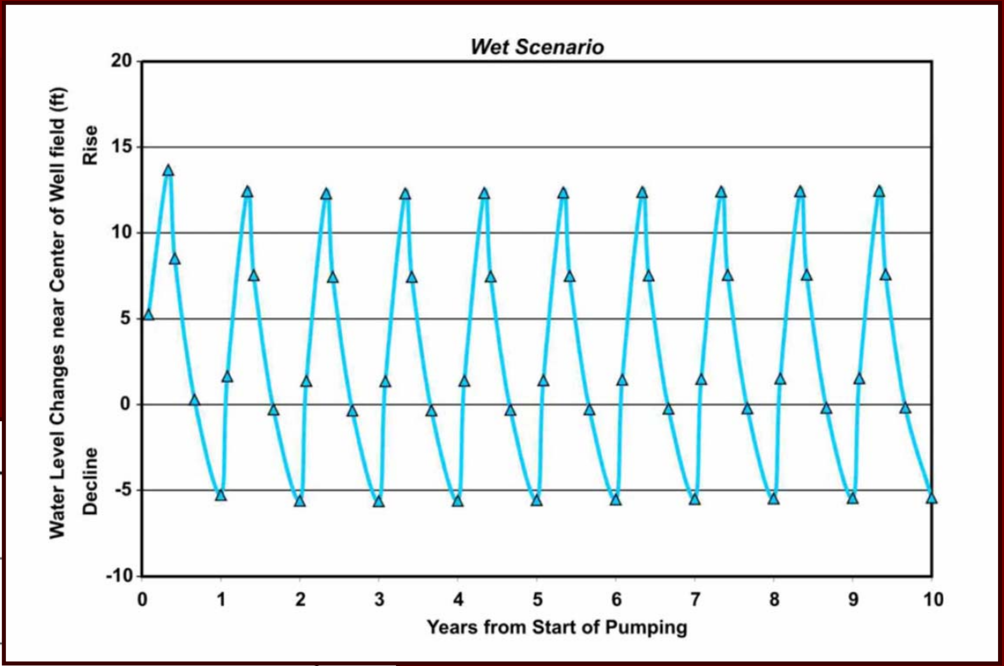
Cost $1.45 - 1000/gal

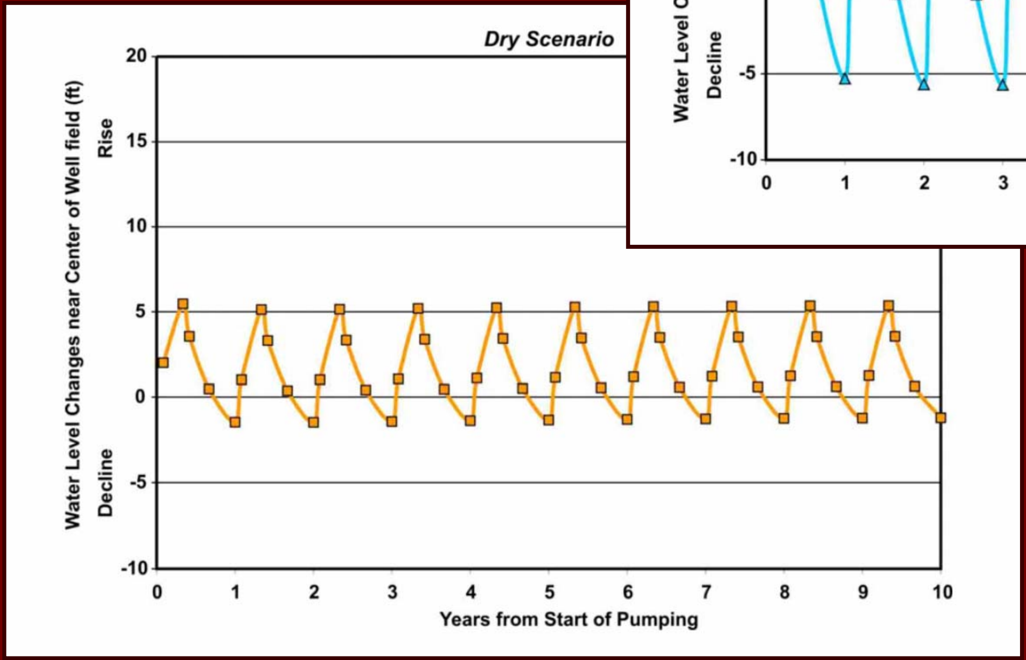


Public Water Supply Impacts (cont.)

10 yrs of simulated aquifer water level

4 months injection
8 months recovery

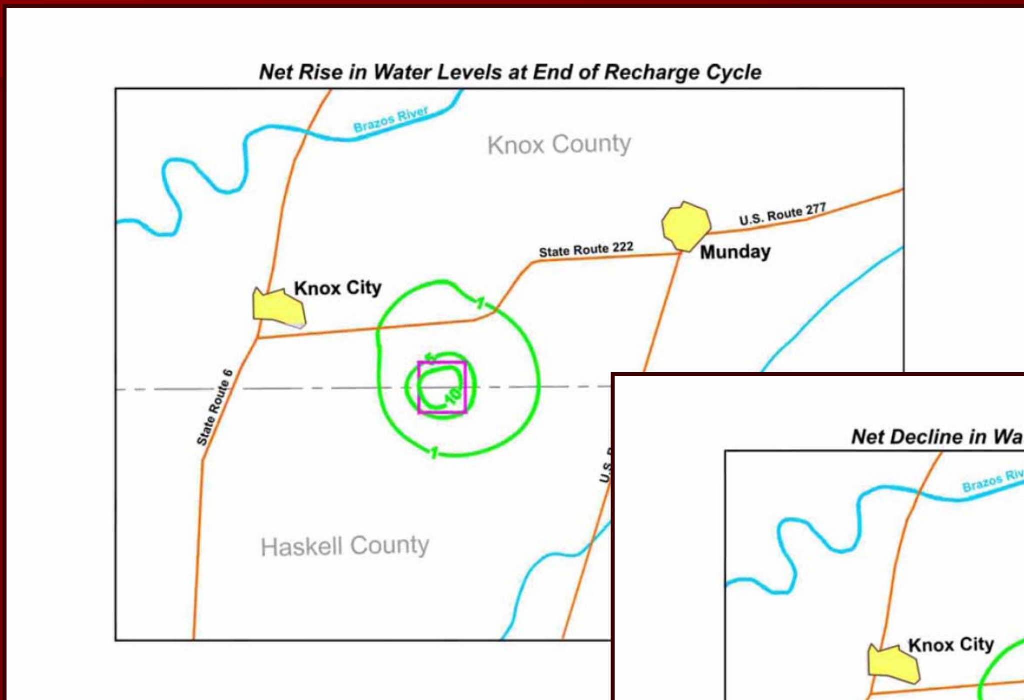




Wet – 3600 ac/ft recharge
3000 ac/ft recovered

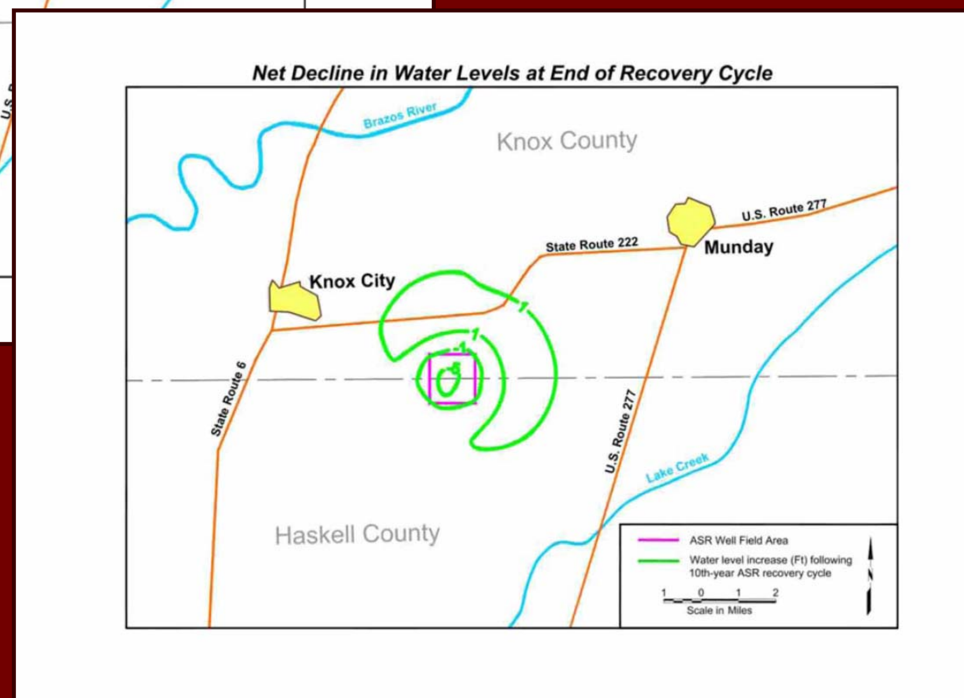
Dry – 1360 ac/ft recharge
1000 ac/ft recovered

Public Water Supply Impacts (cont.)



Wet Scenario Water Table
Seasonal Response

Aquifer covers ~ 16 mi^2



Edge of Spreading Grounds:

+5’ recharge mound

- 1’ recovery depression

Public Water Supply Impacts (cont.)

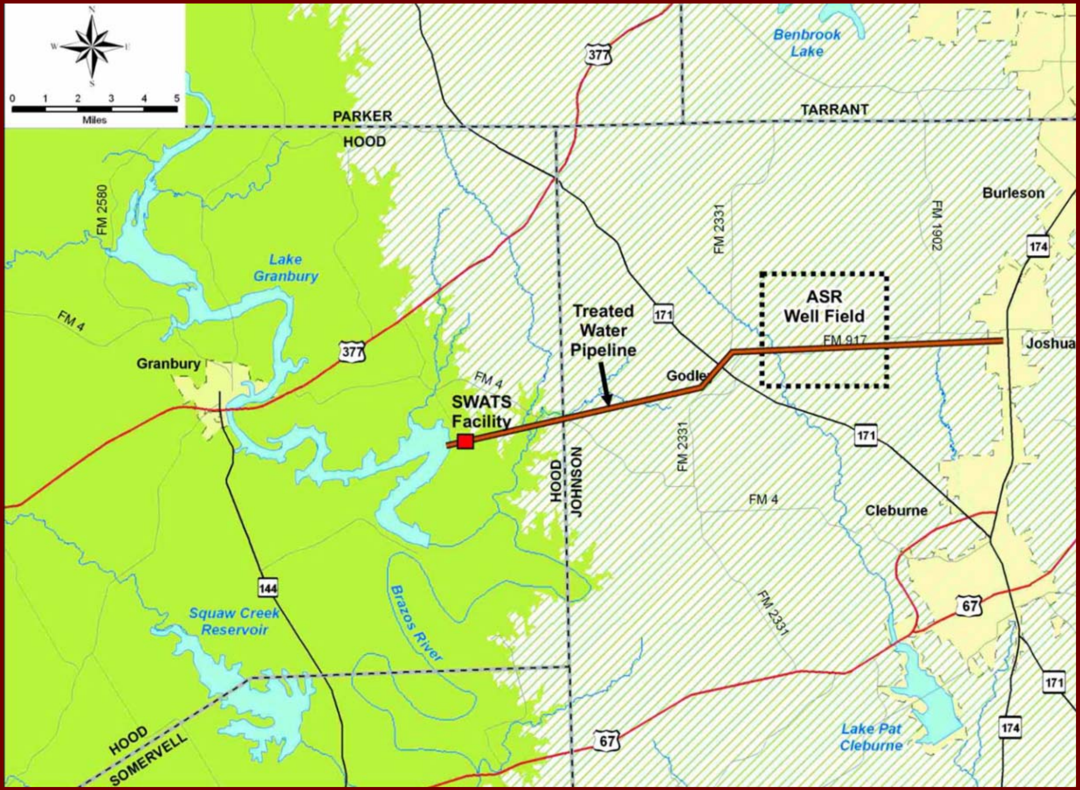
Classic ASR project

- 2600 ac/ft/yr treated water injected & recovered

- 26 ASR wells projected
- 1,100’ to 1,200’ deep
- injection/recovery ± 250 gpm

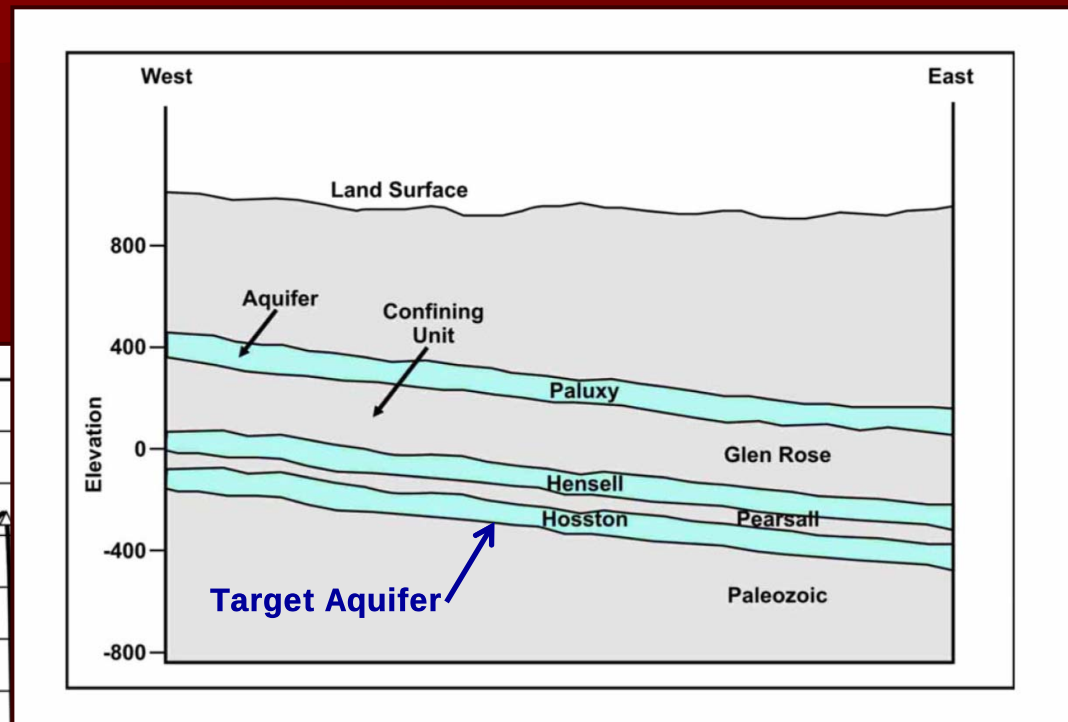
- Public Water Supply

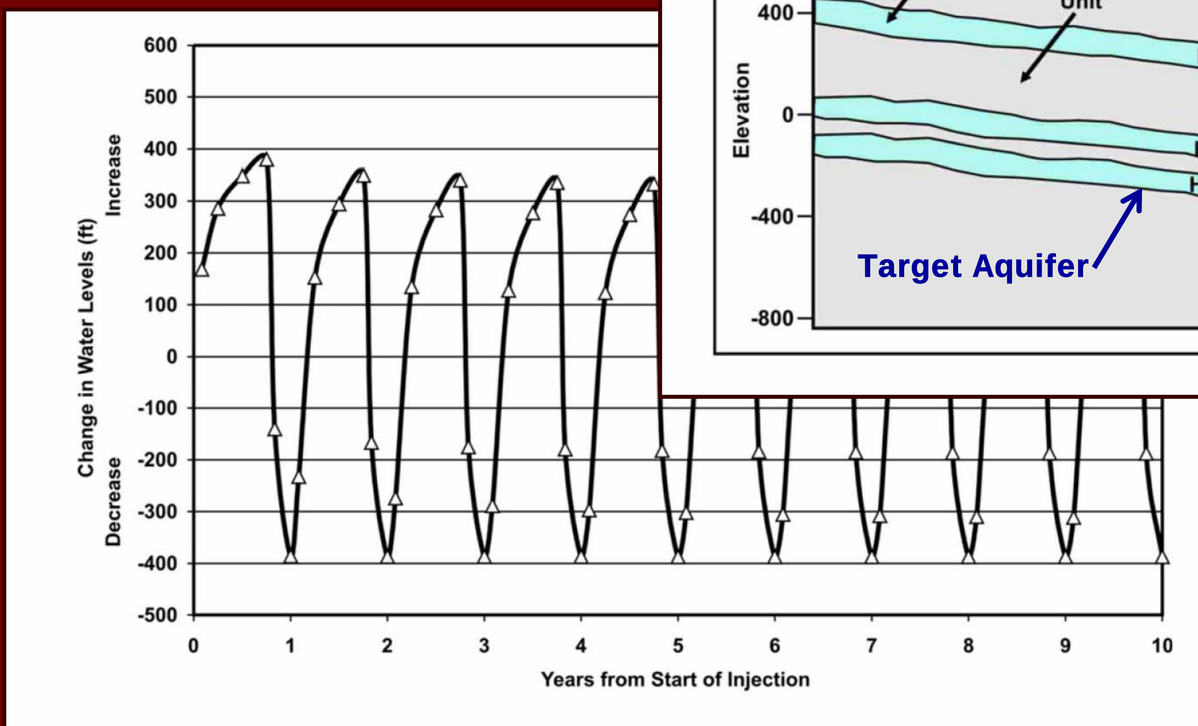
- Cost $6.21 – 1000/gal



Public Water Supply Impacts (cont.)

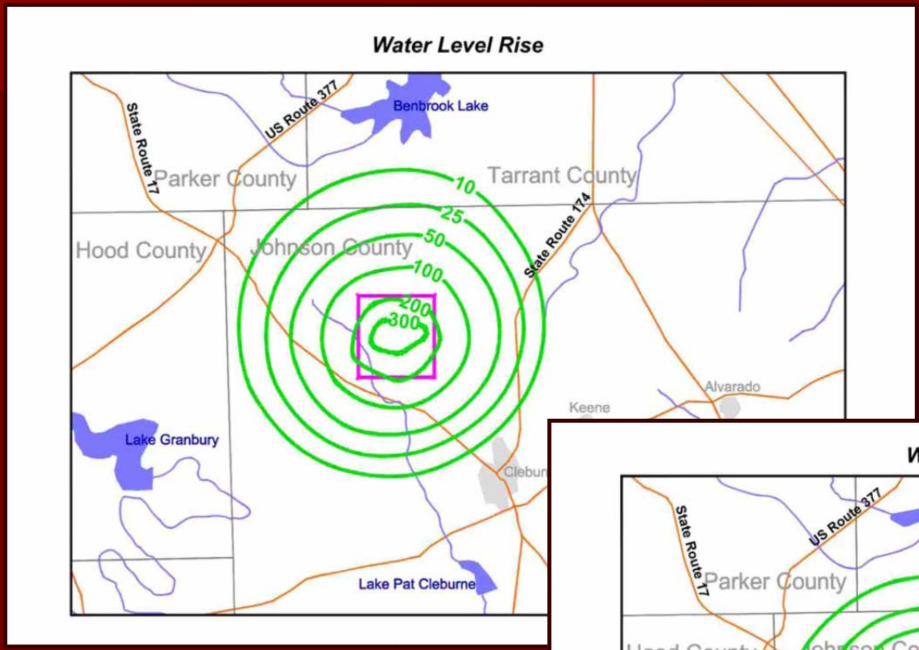
Trinity Aquifer System
- Hosston Unit 50’ to 100’
- highly transmissive
- confined/artesian





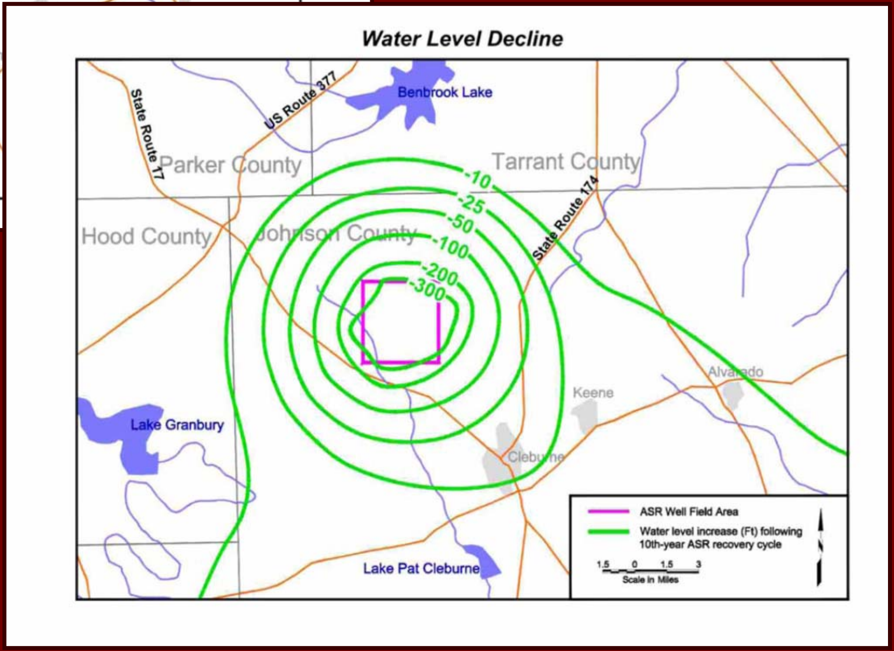
Simulations:
- 750’ oscillations
- 350’ + potential
- 400’ - potential

Public Water Supply Impacts (cont.)



+200’ pressure mound covers ~9 mi^2

-300’ cone of depression after recovery ~ 9 mi^2



Water injected for 9 months
Recovery for 3 months

Public Water Supply Impacts (cont.)

- Adverse water quantity impacts to other users occur during recovery of injected water
  - – Aggressive recovery practice driven by cost
  - – Operational reliability of other systems affected
    - Pressure systems
    - Pumping rates
    - Operational costs
  - – Future public water system plans may be affected
- ARS/AS may not be well supported by Montana water rights statute or rules

- Questions